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Indian Standard
SPECIFICATION FOR NON-IGNITABLE AND SELF-EXTINGUISHING BOARDS (WITH MINERAL BASE) FOR ELECTRICAL PURPOSES

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6

November 1967

Indian Standard
SPECIFICATION FOR NON-IGNITABLE AND SELF-EXTINGUISHING BOARDS (WITH MINERAL BASE) FOR ELECTRICAL PURPOSES

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Indian Standard
SPECIFICATION FOR NON-IGNITABLE AND SELF-EXTINGUISHING BOARDS (WITH MINERAL BASE) FOR ELECTRICAL PURPOSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 13 October 1967, after the draft finalized by the Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Non-ignitable and self-extinguishing boards are used as insulating materials in such electrical equipments where fire hazards are anticipated due to the normal operating conditions of the equipment.

0.3 Non-ignitable boards which are generally made of bonded asbestos fibre have a smooth finish on both faces and are uniform in thickness. The material withstands repeated exposure to an electric arc in air or a flame of high intensity and possesses relatively good mechanical and machining properties. The material is suitable for arc shields on control apparatus and the like.

0.4 Non-ignitable boards should not be regarded as satisfactory insulating material in damp situations. If these boards are used in situations where they are liable to absorb moisture, a resulting reduction in electrical insulating properties should be recognized. The boards should, therefore, be suitably protected.

0.5 Non-ignitable boards are also manufactured for building and similar purposes and selection may be necessary to obtain boards to comply with the requirement of this standard.

0.6 Self-extinguishing boards are generally made from impregnated cement bonded asbestos fibre and manufactured by one pressing, that is, they are not built up of two or more separately pressed boards. They differ from non-ignitable boards in that they are impregnated to increase their moisture resistance thus improving their electrical properties. They possess good insulation characteristics but are not intended to withstand high temperatures on the direct impingement of an electric arc. The materials used to improve the moisture resistance and electrical properties may be flammable. These boards contain a small percentage of bitumen or other fusible material and are suitable for terminal boards, relay boards, switchboard panels and the like.

0.7 The tests required are mainly intended to confirm the quality of boards made from cement bonded asbestos fibre. There may be other materials which may meet the requirements of this standard but additional tests may be needed to show that they are satisfactory for the purpose for which cement bonded asbestos fibre boards have long been used in the electrical industry.

0.8 Materials purporting to comply with this standard shall be capable of meeting all the requirements of this standard, but it is not considered necessary that all the tests mentioned in the standard should be demanded by the purchaser.

0.9 In preparing this standard, assistance has been derived from the following:

Draft B.S. 66/3994 Specification for asbestos cement boards (incombustible) for electrical purposes (*revision of* B.S. 3497 : 1962). British Standards Institution.

Draft B.S. 66/3995 Specification for impregnated asbestos cement boards (self-extinguishing) for electrical purposes (*revision of* B.S. 3503 : 1962). British Standards Institution.

0.10 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements of four classes of non-ignitable boards and self-extinguishing boards for electrical purposes (*see* **3**).

2. TERMINOLOGY

2.0 For the purpose of this standard, in addition to the definitions given in IS : 4249-1967†, the following definitions shall also apply.

2.1 Non-ignitable — A material, which when heated as prescribed in Appendix A of IS : 4249-1967†, neither burns nor gives off inflammable vapours.

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*Rules for rounding off numerical values (*revised*).

†Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials (*under print*).

2.2 Self-Extinguishing — A material, which having ignited, when heated as prescribed in Appendix A, does not continue to burn for more than one minute after the source of ignition is removed.

2.3 Edgewise — The direction from one edge to the opposite edge of the original board.

3. CLASSIFICATION

3.1 Non-ignitable Board Class 1 — It is made from cement bonded asbestos fibre from 2·5 to 15 mm in thickness. This class includes materials suitable for arc shields on control apparatus and the like where close limits of dimensions are not required.

3.2 Non-ignitable Board Class 2 — It is made from bonded asbestos fibre up to 15 mm in thickness. This material has a smooth finish on one side only. Its mechanical characteristics are not so good as those of Class 1. These are also suitable for arc shields on control apparatus and the like.

3.3 Non-ignitable Board Class 3 — It is made from bonded asbestos fibre up to 15 mm in thickness. These boards have a rougher finish than those of Class 2 and in general are more brittle. These materials are suitable for structural purposes and as barriers in switches, cubicles and the like.

3.4 Non-ignitable Board Class 4 — This class includes asbestos mill board and similar semi-flexible materials made of asbestos fibre with the addition of a small percentage of binder up to a thickness of 6 mm. The material is seriously affected with respect to its physical properties when subjected to repeated exposure to an electric arc in air or flame of high intensity.

3.5 Self-Extinguishing Board — It is made from impregnated cement bonded asbestos fibre by one pressing from 2·5 to 40 mm in thickness.

NOTE — Although limits are given only for boards of certain thickness, boards are made in greater thicknesses also. For boards of thickness higher than specified, the limits and test methods should be fixed up by agreement between the purchaser and the supplier.

4. NON-IGNITABLE BOARDS

4.1 Finish — Boards shall be smooth and uniformly finished according to class requirement and shall be free from local defects and surface imperfections.

4.2 Flatness — A board shall be tested for flatness by being placed concave side up, without restraint on a flat surface, and a light straight edge placed on it. The departure at any point of the surface of the board from the straight edge in any direction of the board shall not exceed the appropriate value given in Table 1.

TABLE 1 FLATNESS

(*Clause* 4.2)

CLASS OF BOARD	MAXIMUM PERMISSIBLE DEPARTURE UNDER STRAIGHT EDGE OF LENGTH		
	900 mm	600 mm	300 mm
1	3·0	1·5	0·4
2	4·5	2·0	0·6
3	6·0	3·0	0·8
4	7·5	4·5	1·0

4.3 Tolerance on Thickness — The thickness of a board at any point shall not differ from the nominal thickness by more than the appropriate value given in Table 2.

TABLE 2 TOLERANCE IN THICKNESS

CLASS OI BOARD	TOLERANCE ON THICKNESS PLUS OR MINUS mm
1	0·25
2	0·35
3	0·75
4	0·25

4.4 Electric Strength (Proof Test) — Any board of Classes 1, 2 and 4 when tested as described in Appendix B, in air at 90°C, shall withstand for one minute without failure the appropriate proof stress given in Table 3.

NOTE — An electric strength test is not required on Class 3 material.

TABLE 3 ONE MINUTE PROOF TEST IN AIR (ELECTRIC STRENGTH)

NOMINAL THICKNESS mm	MINIMUM VOLTS PER mm		
	Class 1	Class 2	Class 3
Up to 2·5		2 000	1 200
From 2·5 to 10	1 000	1 000	1 000
Above 10	800	800	—

4.5 Surface Electric Strength (Proof Test) in Air — Any board when tested as described in Appendix C, in air at 90°C, shall withstand for one minute without breakdown occurring over the surface, the appropriate proof stress given in Table 4. In the case of Class 2 boards, the test shall be conducted on the rough surface.

TABLE 4 ONE MINUTE PROOF TEST IN AIR (SURFACE ELECTRIC STRENGTH)

CLASS OF BOARD	MINIMUM VOLTAGE kV
1	3·0
2	2·0
3	2·0
4	12·0

4.6 Fuse Wire Test — When tested as described in Appendix C of IS : 4249-1967* boards of Classes 1, 2 and 3 shall withstand ten applications of the fuse wire test without the surface being rendered conducting. This condition is determined by a measurement of the leakage current made immediately after each fusing and this current should not exceed one ampere.

NOTE — A fuse wire test is not required on Class 4 material.

4.7 Carbon Arc Test — When boards of Classes 1, 2 and 3 are tested as described in Appendix A of IS : 4249-1967*, the time before penetration occurs shall be not less than the time given in Table 5.

TABLE 5 CARBON ARC TEST

NOMINAL THICKNESS mm	TIME BEFORE PENETRATION		
	Class 1 seconds	Class 2 seconds	Class 3 seconds
2·5	35	25	25
5	60	45	45
10	80	60	60
Above 10 up to and including 15	60	45	45

4.8 Spirit Burner Test — When a board of Class 4 is tested as described in Appendix A, it shall show no sign of combustion at any time during one minute's exposure to the flame.

NOTE — The spirit burner test is not required for Classes 1, 2 and 3 materials.

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*Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials (*under print*).

4.9 Deformation Under Compression — When a board of Classes 1, 2 and 3 is tested as described in Appendix D, the reduction in thickness of the specimen shall not be greater than 5 percent nor shall mechanical failure occur, such as cracking or breaking when it is subjected for one minute to a load of 4 500 kgf.

NOTE — This test is not required on Class 4 material.

4.10 Crushing Strength — When determined as described in Appendix E, the crushing strength shall be not less than 1 055 kgf/cm².

4.11 Shear Strength — The shear strength of a board of Classes 1, 2 and 3, when determined as described in Appendix F, shall not be less than the appropriate value given in Table 6.

NOTE — This test is not required on Class 4 material.

TABLE 6 SHEAR STRENGTH

NOMINAL THICKNESS mm	MINIMUM SHEAR STRESS		
	Class 1 kgf/cm²	Class 2 kgf/cm²	Class 3 kgf/cm²
Up to and including 2·5	350	175	175
Over 2·5 to 5	280	140	140
Over 5 to 15	210	105	105

4.12 Cross-Breaking Strength — When determined as described in Appendix G, the cross-breaking strength shall be not less than 300 kgf/cm².

4.13 Machinability — Any board of Class 1 shall be capable of being machined by normal operations, such as turning, drilling, milling and shaping. Boards of Classes 2 and 3 shall be capable of being sawn and drilled without showing signs of splitting, cracking or chipping. A board of Class 4 shall be capable of being punched and cut with shears without showing signs of raggedness.

5. SELF-EXTINGUISHING BOARDS

5.1 Finish — Boards shall be uniformly finished and free from local defects and surface imperfections. The boards may have various surface treatments and the two faces of the board may be different from each other.

5.2 Flatness — Any board tested for flatness shall be placed concave side up without restraint on a flat surface and a light straight edge placed on it. The departure at any point of the surface of the board from the straight edge in any direction of the board shall not exceed 3·2 mm under a 900 mm straight edge, 1·4 mm under a 600 mm straight edge or 0·35 mm under a 300 mm straight edge.

5.3 Tolerance on Thickness — The thickness of a board at any point shall not differ from the nominal thickness, by more than ±0·25 mm for boards up to and including 25 mm nominal thickness and ±0·4 mm for boards above 25 mm up to and including 40 mm nominal thickness.

5.4 Electric Strength (Proof Test) — Any board, when tested as described in Appendix B in air at 90°C, shall withstand for one minute without breakdown the appropriate test voltage for its nominal thickness according to Fig. 1.

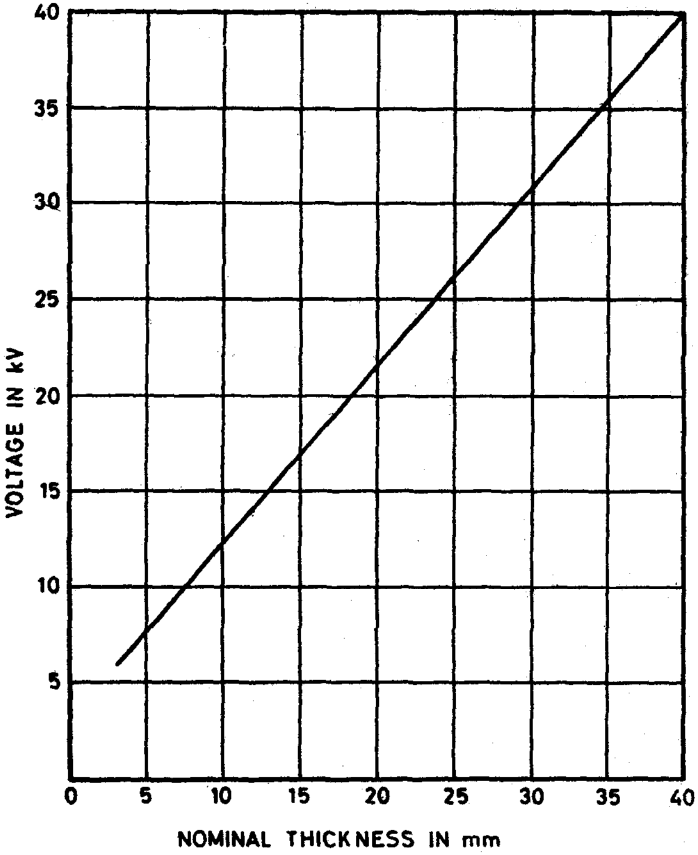

FIG. 1 ELECTRIC STRENGTH PROOF VOLTAGE

5.5 Surface Electric Strength (Proof Test) — Any board, when tested as described in Appendix C in air at room temperature, shall withstand 14 kV for one minute without breakdown occurring over the surface.

5.6 Edgewise Electric Strength (Proof Test) — Any board, when tested as described in Appendix H in oil at 90°C, shall withstand 10 kV for one minute without any sign of breakdown occurring.

5.7 Insulation Resistance — When determined as described in Appendix J, the insulation resistance shall be not less than 1 000 M.

5.8 Spirit Burner Test — When a board is tested as described in Appendix A, it shall not continue to burn for longer than 60 seconds.

5.9 Deformation Under Compression — When a board is tested, as described in Appendix D, the reduction in thickness of the specimen shall not exceed 2·0 percent, nor shall failure occur by cracking or breaking when subjected for one minute to a load of 2 250 kgf.

5.10 Crushing Strength — When determined as described in Appendix E, the crushing strength shall be not less than 700 kgf/cm².

5.11 Shear Strength — The shear strength of a board, when determined as described in Appendix F, shall be not less than the appropriate value given in Table 7.

TABLE 7 SHEAR STRENGTH

NOMINAL THICKNESS mm	MINIMUM SHEAR STRESS kgf/cm²
2·5	280
Above 2·5 up to and including 5	246
,, 5 ,, ,, ,, ,, 15	210
,, 15 ,, ,, ,, ,, 25	176
,, 25 ,, ,, ,, ,, 40	140

5.12 Cross-Breaking Strength — When determined as described in Appendix G, the cross-breaking strength shall be not less than 315 kgf/cm² for boards up to and including 25 mm nominal thickness and 265 kgf/cm² for boards above 25 mm nominal thickness.

5.13 Bending Test for Boards 5 mm Thick and Above — Any board of nominal thickness 5 mm and above, when tested as described in Appendix K, shall withstand for two hours the appropriate maximum bending stress without failure or showing any sign of cracking. The permanent set of the test piece shall not exceed the appropriate values given in Table 8.

TABLE 8 BENDING TEST

(*Clause* 5.13)

NOMINAL THICKNESS	MAXIMUM PERMANENT SET	
	Test Temperature = 27°C Maximum Stress = 140 kgf/cm²	Test Temperature = 90°C Maximum Stress = 70 kgf/cm²
mm	mm	mm
5	0·15	0·25
10	0·20	0·25
15	0·25	0·50
25	0·38	0·50
30	0·38	0·76
40	0·38	0·76

5.14 Machinability — Any board shall be capable of being machined by normal operations, such as turning, drilling, milling and shaping, without showing signs of splitting, cracking or chipping.

5.15 Water Absorption — The amount of water absorbed by a board of any thickness after 24 hours immersion, when determined as described in Appendix L, shall not exceed 0·2 percent.

5.16 Effect of Heat Treatment — Any board, when tested as described in Appendix M, shall show no sign of deterioration or substantial exudation of the impregnant.

APPENDIX A

(*Clauses* 2.2, 4.8 *and* 5.8)

METHOD OF CARRYING OUT THE SPIRIT BURNER TEST

A-1. PREPARATION OF TEST PIECE

A-1.1 Non-ignitable Boards — Take three test pieces 15 mm wide of thickness of the board under test and of sufficient length to give a free length of not less than 100 mm when clamped as described in **A-3.2.**

A-1.2 Self-Extinguishing Boards — Take three test pieces 15 mm wide of the thickness of the board under test if this is 6·5 mm or less and of sufficient length to give a free length of not less than 100 mm when clamped as described in **A-3.2** retaining any surface treatment that may be on the test piece. Machine boards more than 6·5 mm thick to a thickness of 6·5 mm and prepare duplicate sets of test pieces so that both treated surfaces are tested.

A-1.3 Condition the test pieces in accordance with Appendix F of IS : 4249-1967*.

A-2. SPIRIT BURNER

A-2.1 Use a spirit burner of the pattern shown in Fig. 4 of IS : 4249-1967* and having the essential dimensions given.

A-2.2 Use good quality 66 O.P. industrial methylated spirit containing 5 percent of wood naphtha as the fuel.

A-3. PROCEDURE

A-3.1 Operate the burner with the control value more than one-half turn open and with the level of the fuel in the reservoir 750 ± 75 mm above the base of the burner. Confirm the satisfactory operation of the burner by inserting a bare copper wire 0·71 mm diameter, having a free length of not less than 100 mm in the flame of the burner in the position to be occupied by the test piece. The flame is satisfactory for this test if the wire melts in less than 6 seconds.

A-3.2 With the burner functioning satisfactorily, clamp the test piece so that it rests in the flame of the burner with its long axis horizontal and the 15 mm dimension facing the flame 50 mm above the top of the burner. Not less than 100 mm of the test piece is to project from the jaws of the clamp and the end of the test piece is to be vertically above the edge of the burner as shown in Fig. 5 of IS : 4249-1967*.

A-3.3 Subject the test piece to the flame for one minute.

A-3.4 In the case of non-ignitable boards, verify any apparent burning of the test piece by momentary removal of the flame and observation in subdued light. Combustion is established if the test piece continues to burn for more than one second after removal of the parent flame at any time between 5 and 50 seconds.

A-3.5 In the case of self-extinguishing boards, remove the flame and note the time for which the test piece continues to burn. If the flame reaches within 25 mm of the clamp, discard the results and test a new and longer test piece to ascertain the time required for extinction. Determine the mean value of tests on three test pieces.

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*Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials (*under print*).

APPENDIX B

(*Clauses* 4.4, 5.4, C-1.1, C-2.1, C-3.1 *and* H-3.1)

METHODS FOR THE DETERMINATION OF ELECTRIC STRENGTH (PROOF TEST IN AIR AT 90°C)

B-1. PREPARATION OF TEST PIECE

B-1.1 Non-ignitable Boards — Take a test piece, not less than 100 mm square, of the thickness of the board under test and heat it in an oven at the temperature $180^{\circ}\,^{+5}_{-0}\,^{\circ}\mathrm{C}$ for 18 to 24 hours. Cool the test piece to 90° ± 2°C in the same oven or immediately transfer it to an oven at 90° ± 2°C and allow the test piece to reach this temperature before making the test.

B-1.2 Self-Extinguishing Boards — Take a test piece, not less than 100 mm square and sufficiently large to avoid flash over and of the thickness of the board under test. Heat the test piece at a temperature of 90° ± 2°C for not less than the appropriate period given below and maintain it at this temperature throughout the test:

Thickness of Test Piece	*Time*
up to and including 15 mm	1 hour
Above 15 mm up to and including 25 mm	2 hours
Above 25	3 hours

B-2. ELECTRODES

B-2.1 The electrodes consists of two solid brass cylinders with their sharp edges rounded off to a radius of approximately 3 mm. The top electrodes shall be 25 mm diameter and 25 mm in height. The bottom electrode shall be 75 mm diameter and 25 mm in height.

B-3. TEST VOLTAGE

B-3.1 Use an alternating test voltage of a frequency between 40 and 60 c/s. It shall be of approximately sine wave-form with crest factor equal to $\sqrt{2} \pm 5$ percent, that is, 1·35 to 1·49 (*see* IS : 2584-1963*).

B-3.2 The crest factor may be checked by means of an oscillograph, a sphere gap or a crest voltmeter in conjunction with a rms voltmeter. The measurement should be made across the material under test.

B-3.3 The peak voltage may be measured directly by means of a peak voltmeter. Alternatively, the voltage may be determined by a voltmeter suitably connected to the input or output side of the testing transformer or to a voltmeter winding provided thereon. If this alternative procedure is adopted the instrument used should be calibrated against a sphere gap up to the full voltage which is to be measured.

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*Methods of test for electric strength of solid insulating materials at power frequencies.

B-3.4 The ratio of the voltage derived from the sphere gap to the voltage indicated on the auxiliary instrument may be dependent upon the presence of the test object or of the sphere gap. It is, therefore, important that the test object or an equivalent load should be in the circuit during calibration. The sphere gap may be disconnected during the actual test, if its absence is known to have a negligible influence on the voltage ratio (*see* IS : 1876-1961*).

B-3.5 Use test equipment capable of maintaining the test voltage up to the instant of breakdown or for the maximum time required. Usually this requirement is met by equipment capable of supplying an output current of not less than 40 mA over the voltage range for which it is intended at all leading power factors between zero and unity.

B-4. PROCEDURE

B-4.1 Arrange the electrodes coaxially in the testing oven and ensure that both electrodes and test pieces are at a temperature of 90° ± 2°C.

B-4.2 Apply a low value of the test voltage between the electrodes and increase its value at a uniform rate so that the proof stress value is reached in about 10 seconds. Maintain the voltage at this value for one minute.

APPENDIX C

(*Clauses* 4.5 *and* 5.5)

METHOD FOR THE DETERMINATION OF SURFACE ELECTRIC STRENGTH (PROOF TEST IN AIR)

C-1. PREPARATION OF TEST PIECE

C-1.1 Non-ignitable Boards — Take a test piece sufficiently large to accommodate the electrodes and dry it at $180^{\circ}{}^{+5}_{-0}$ °C and then cool to 90° ± 2°C in accordance with **B-1**.

C-1.2 Self-Extinguishing Boards — Take a test piece (complete with any surface treatment) sufficiently large to accommodate the electrodes and condition it in accordance with Appendix F of IS : 4249-1967†.

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*Method for voltage measurement by means of sphere gaps (one sphere earthed).

†Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials(*under print*).

C-2. ELECTRODES

C-2.1 The electrodes shall be either two solid brass cylinders 25 mm in diameter and 25 mm high or those specified in **B-2**.

C-3. TEST VOLTAGE

C-3.1 The wave form, the frequency and the method of measuring the test voltage shall be the same as that specified in **B-3**.

C-4. PROCEDURE

C-4.1 Support the test piece on an insulating block and arrange the electrodes so that their flat surfaces are in contact with one surface of the test piece and the nearest distance between the edges of the electrodes is 25 mm.

C-4.2 In the case of non-ignitable boards, heat the electrodes and the test piece in an oven at 90° ± 2°C.

C-4.3 In the case of self-extinguishing boards, make the test on each face of test piece in turn while the test piece is in the controlled atmosphere, or within 3 minutes of removal from it.

C-4.4 Apply a low value of the test voltage between the electrodes and increase its value at a uniform rate so that the specified proof voltage is reached in 10 seconds. Maintain the voltage at this value for one minute.

APPENDIX D

(*Clauses* 4.9 *and* 5.9)

METHOD OF DETERMINING DEFORMATION UNDER COMPRESSION

D-1. PREPARATION OF TEST PIECE

D-1.1 Prepare a test piece consisting of pieces of board 25 ± 0·25 mm square, built up as nearly as possible to a thickness of 25 mm without reducing the thickness of the pieces. Take care to remove the burrs and surface treatment, if any, from all edges of all the pieces.

D-1.2 In the case of self-extinguishing boards of nominal thickness greater than 25 mm, the test piece shall be 25 ± 0·25 mm square and of the thickness of the board under test.

D-2. CONDITIONING

D-2.1 Condition the test pieces in accordance with Appendix F of IS : 4249-1967* and then test at a temperature of 27° ± 10°C.

D-3. PROCEDURE

D-3.1 Apply an initial load of 900 kgf for non-ignitable boards and 50 kgf for self-extinguishing boards, to the test piece in the direction perpendicular to the surface of the board in order to bed the layers together. Make the first thickness measurement with the test pieces under this load. Then increase the load at a uniform rate of 900 kgf/min in the case of non-ignitable boards and 450 kgf/min in the case of self-extinguishing boards till the specified load has been reached (4 500 kgf for non-ignitable boards and 2 250 kgf for self-extinguishing boards). Maintain this load for one minute and then measure the thickness of test piece with the load still applied.

APPENDIX E

(*Clauses* 4.10 *and* 5.10)

METHOD OF DETERMINING CRUSHING STRENGTH

E-1. PROCEDURE

E-1.1 Prepare three test pieces and apply the compressive load to each exactly as in the test for deformation under compression. Increase the pressure steadily at a rate of approximately 350 kgf/min for non-ignitable boards and 450 kgf/min for self-extinguishing boards ignoring the bedding load, until the test piece is seen to fail.

E-2. RESULT

E-2.1 Record the load at failure for each test piece and express the crushing strength of the board under test as the arithmetic mean of the results from the three test pieces.

APPENDIX F

(*Clauses* 4.11 *and* 5.11)

METHOD FOR THE DETERMINATION OF SHEAR STRENGTH

F-1. PREPARATION OF TEST PIECE

F-1.1 Prepare a test piece 95 mm long by 19 ± 0·25 mm wide by the thickness of the board under test.

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*Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials (*under print*).

F-1.2 In the case of self-extinguishing boards, remove the dry surface treatment before preparing the test piece. For boards thicker than 25 mm machine the test piece down to 25 mm thick retaining one of the original surfaces.

F-2. CONDITIONING

F-2.1 Condition the test piece in accordance with Appendix F of IS : 4249-1967* and then test at a temperature of 27° ± 10°C.

F-3. PROCEDURE

F-3.1 Subject the test piece to a shear load by means of a circular punch and die of the dimensions shown in Fig. 2, the punch being a running fit in the die. Increase the load steadily at such a rate that the test piece shears in approximately two minutes from the time of the initial application of the load.

F-4. RESULT

F-4.1 Compute the shear stress from the following formula:

$$S = \frac{W}{2\,BTK}$$

where

S = shear stress in kgf/cm^2,
W = shear load in kgf,
B = width of test piece in cm,
T = thickness of test piece in cm, and
K = constant to allow for the curvature of sheared surface (1·016).

APPENDIX G

(*Clauses* 4.12 *and* 5.12)

METHOD OF DETERMINING CROSS-BREAKING STRENGTH

G-1. TEST PIECES

G-1.1 Use test pieces 12·5 ± 0·5 mm wide and of length 24 to 30 times the measured thickness of the board under test. The thickness of the test piece shall be the thickness of the board under test, except that where this exceeds 9·5 mm the thickness of the test piece shall be reduced to 9·5 mm by machining one surface. Test three test pieces from each board to be tested.

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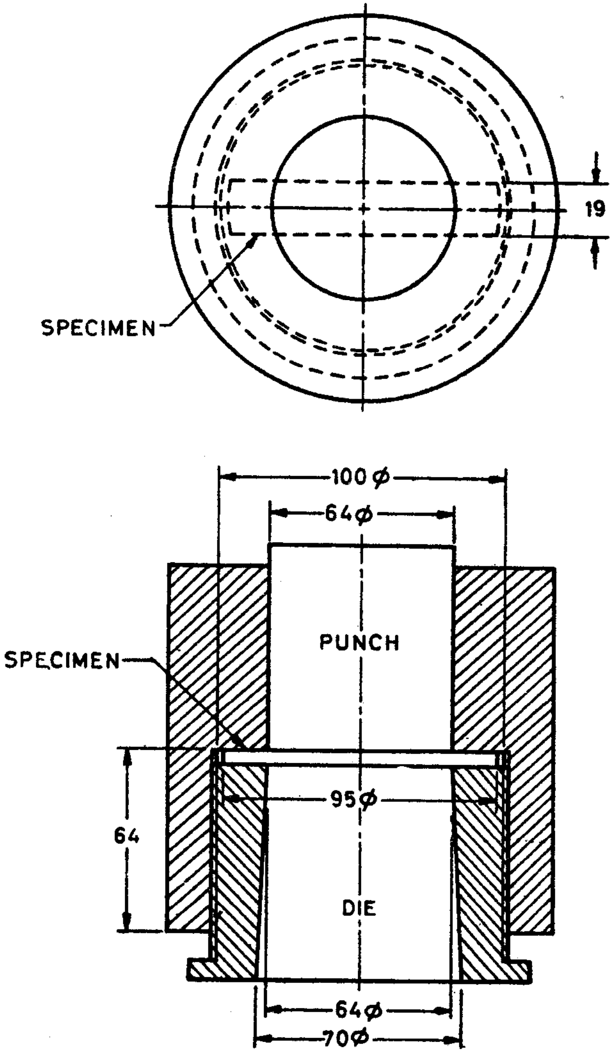
*Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials (*under print*).



All dimensions in millimetres.

FIG. 2 PUNCH AND DIE FOR SHEAR STRENGTH TEST

G-2. PROCEDURE

G-2.1 Carry out the test at a temperature of 27° ± 10°C. Measure the width and thickness of the test piece to the nearest 0·02 mm. Lay each test piece symmetrically across two parallel V-shaped supports with an original face in contact with the supports. Adjust the distance between the supports to sixteen times the measured thickness of the test piece to the nearest 0·8 mm. Apply a load squarely across the width of each test piece by means of a V-shaped block parallel to and midway between the two supports. Use supports and a block with 1·6 mm radius contact edges not less than 25 mm long. Increase the load steadily and at such a rate that the test piece fractures in 15 to 45 seconds.

G-3. RESULT

G-3.1 Calculate the cross-breaking strength of each test piece from the following formula:

$$\text{Cross-breaking strength in kgf/cm}^2 = \frac{KWL}{BD^2}$$

where

K = 1·5.
W = breaking load in kgf,
L = distance between supports in centimetres,
B = width of test piece in centimetres, and
D = thickness of test piece in centimetres.

G-3.2 Express the cross-breaking strength of the board as the arithmetic mean of the results from the three test pieces.

APPENDIX H

(*Clause* 5.6)

METHOD FOR THE DETERMINATION OF EDGEWISE ELECTRIC STRENGTH (PROOF TEST IN OIL AT 90°C)

H-1. PREPARATION OF TEST PIECE

H-1.1 Take a rectangular test piece (complete with any surface treatment) approximately 100 mm long by 25 ± 0·2 mm wide and of the thickness of the board under test. Finish the long edges as parallel planes at right angles to the surface of the board and place the test piece between metal plates so that they make good contact over the whole area of the long edges and form parallel electrodes for applying the test voltage to the 25 mm width of the test piece. For thin boards use two test pieces suitably placed (that is, with their long edges at a convenient angle) to support the upper electrode.

H-2. ELECTRODE

H-2.1 The electrodes shall consist of two parallel metal plates. The electrodes shall be of size sufficient to overlap the edges of the test piece by not less than 15 mm. The edges and corners of the electrodes should be suitably rounded off when necessary to avoid flash over from edge to edge (*see* **5.2** of IS : 2584-1963*).

H-3. TEST VOLTAGE

H-3.1 The wave form, the frequency and the method of measuring the test voltage shall be the same as that specified in Appendix B.

H-4. PROCEDURE

H-4.1 Place the assembly of test piece and electrodes in insulating oil complying with IS : 335-1963† which is at a temperature of 90° ± 2°C. Maintain the assembly in oil at this temperature for not less than half an hour and not more than one hour.

H-4.2 Apply a low value of the test between the electrodes and increase its value at a uniform rate so that the proof voltage of 10 kV is reached in about 10 seconds. Maintain the voltage at this value for one minute.

H-4.3 In assessing the effect of the applied voltage take no account of any deterioration of any surface treatment due to the influence of the insulating oil.

APPENDIX J

(*Clause* 5.7)

METHOD FOR DETERMINING INSULATION RESISTANCE

J-1. TEST PIECE

J-1.1 Use a test piece (complete with any surface treatment) at least 75 mm square of the thickness of the board under test.

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*Method of test for electric strength of solid insulating materials at power frequencies.

†Specification for insulating oil for transformers and switchgear (*revised*).

J-1.2 Drill four holes through the test piece, normal to the surface, with centres 25 ± 1 mm apart, the centres of the holes forming the corners, of a square. Make the holes of such diameter that after reaming with a reamer having a taper of approximately 2 percent, the diameter of each hole at the larger end is not less than 4·5 mm and not greater than 5·5 mm. Drill the holes at least 25 mm from the cut edges and ream them in the same direction throughout their full length. Ensure that the surfaces of the test piece are clean. In cases of doubt clean the surfaces with a petroleum solvent.

NOTE — Alternatively, two test pieces may be used with three holes drilled in each in a right-angled triangle configuration, provided that in other respects the above requirements are met.

J-2. ELECTRODES

J-2.1 Use clean brass or steel taper pin electrodes of approximately 5 mm diameter with a taper of approximately 2 percent and of length sufficient to extend at least 2 mm on each side of the test piece.

J-3. PROCEDURE

J-3.1 Dry the test piece in an oven at a temperature of 50° ± 2°C for 24 ± 1 hour. After allowing the test piece to cool to ambient air temperature, immerse it in distilled water at a temperature of 27° ± 2°C for 24 ± 1 hour.

J-3.2 Remove the test piece from the water and after wiping the exposed surfaces dry with a clean cloth, press the electrodes into the holes in the test piece so that they fit tightly and extend at least 2 mm on each side of the test piece.

J-3.3 In an atmosphere of 65 ± 5 percent relative humidity at a temperature of 27° ± 2°C apply a potential difference of 500 ± 50 V (direct current) between the electrodes and after one minute measure the insulation resistance between each contiguous pair.

J-3.4 Make all measurements within 5 minutes of removal of the test piece from the water.

J-4. RESULT

J-4.1 Express the insulation resistance of the sheet as the arithmetic mean of the four measurements.

APPENDIX K

(*Clause* 5.13)

METHOD FOR THE DETERMINATION OF BENDING STRESS

K-1. PREPARATION OF TEST PIECE

K-1.1 Prepare a test piece of the following dimensions:

Length = $8T + 65$ mm
Width = $2T$
where T is the nominal thickness in mm of the board under test.

K-1.2 Cut a shallow V-notch across the width of the test piece at right angles to its length so that the distance between the root of the notch and one end of the test piece is 6·5 mm. Bed down the bottom of the root of the notch to the knife edge of the loading stirrup before commencing the test.

K-2. PROCEDURE

K-2.1 Carry out the bending test at a temperature of 27° ± 10°C and at 90° ± 2°C.

K-2.2 Support the test piece as a cantilever in a clamp whose edges have radii of approximately 1·6 mm. The width of the test piece is in the horizontal plane, and the distance between the root of the notch and the edge of the clamp is 8 times the nominal thickness of the board under test. Fit the notch with a suitable stirrup for applying the load. Compute the load required to give the appropriate bending stress specified in Table 8 from the following formula:

$$W = \frac{FBD^2}{6L}$$

where

W = load in kgf,
F = maximum bending stress in kgf/cm^2,
B = width of the test piece in cm,
D = measured thickness of the test piece in cm, and
L = cantilever length in cm.

$$\text{Maximum bending stress} = \begin{cases} 140 \text{ kgf/cm}^2 \text{ at } 27^\circ\text{C} \\ 70 \text{ kgf/cm}^2 \text{ at } 90^\circ\text{C} \end{cases}$$

K-2.3 Test at room temperature (27° ± 10°C). Assemble on a stand the test piece in the clamp with a micrometer arranged to measure the movement of the stirrup. Take zero reading with the stirrup in position. Suspend the appropriate load from the stirrup and maintain for two hours. Remove the load and, after 30 minutes, measure the vertical movement of the stirrup and take this as the permanent set of the test piece.

K-2.4 Test at 90°C — Place the apparatus and test piece with the stirrup in position, but without the load, in an oven that had previously been heated to 90° ± 2°C and take zero reading after one hour for test pieces up to 15 mm and after two hours for test pieces above 12·5 mm and up to 40 mm thick. Suspend the appropriate load from the stirrup and maintain for two hours. After this time open the oven, remove the load without disturbing the stirrup and close the oven as quickly as possible. After 30 minutes measure the vertical movement of the stirrup from its original position and take this as the permanent set of the test piece. The temperature of the oven shall be maintained at approximately 90°C until the measurement has been made.

APPENDIX L

(*Clause* 5.15)

METHOD FOR THE DETERMINATION OF WATER ABSORPTION

L-1. PREPARATION OF TEST PIECE

L-1.1 Prepare a test piece 40 mm square, with the four edges freshly cut and any surface treatment removed by machining.

L-2. CONDITIONING

L-2.1 Condition the test piece in accordance with Appendix F of IS : 4249-1967*.

L-3. PROCEDURE

L-3.1 Weigh and immerse in distilled water at temperature of 27° ± 2°C. After 24 hours immersion take it from the water, and after removing the surface moisture by wiping, weigh again. The weight should be determined to the nearest milligramme in each case.

L-4. RESULT

L-4.1 Compute the percentage absorption of water on the weight of the conditioned test piece and state the original thickness of the test piece.

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*Classification and methods of test for the non-ignitable and self-extinguishing properties of solid electrical insulating materials (*under print*).

APPENDIX M

(*Clause* 5.16)

METHOD FOR THE DETERMINATION OF EFFECT OF HEAT TREATMENT

M-1. PREPARATION OF TEST PIECE

M-1.1 Prepare a test piece 40 mm square and remove the surface treatment, if any.

M-2. PROCEDURE

M-2.1 Place the test piece on a sheet of white paper and subject it to a temperature of 120° ± 2°C for one hour. Examine the surfaces and edges of the test piece and the paper for evidence of exudation of the impregnant.

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